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TITLE: **REMOTE CONTROL FOR A PLUG-DROPPING HEAD**

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FIELD OF THE INVENTION

The field of this invention relates to methods and devices usable in the field of oil and gas exploration and production, more specifically devices and methods related to cementing operations involving the cementing of a liner by dropping or by pumping down a plug.

BACKGROUND OF THE INVENTION

Cementing operations have involved the use of plugs as a way of correctly positioning the cement when setting a liner. Some mechanisms have employed the use of pressure or vacuum to initiate plug movement downhole for proper displacement of the cement to its appropriate location for securing the liner properly. The early designs were manual operations so that when it was time to release a plug for the cementing operation, a lever was manually operated to accomplish the dropping of the plug. This created several problems because the plug-dropping head would not always be within easy access of the rig floor. Frequently, depending upon the configuration of the particular well being drilled, the dropping head could be as much as 100 ft. or more in the derrick. In order to properly actuate the plug to drop, rig personnel would have to go up on some lift mechanism to reach the manual handle. This process would have to be repeated if the plug-dropping head had facilities for dropping more than one plug. In those instances, each time another plug was to be dropped, the operator of the handle would have to be

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hoisted to the proper elevation for the operation. In situations involving foul weather, such as high winds or low visibility, the manual operation had numerous safety risks. Manual operations used in the past are illustrated in U.S. Patent 4,854,383. In that patent, a manual valve realignment redirected the flow from bypassing the plug to directly above it so that it could be driven downhole.

Hydraulic systems involving a stationary control panel mounted on the rig floor, with the ability to remotely operate valves in conjunction with cementing plugs, have also been used in the past. Typical of such applications is U.S. Patent 4,782,894. Some of the drawbacks of such systems are that for unusual applications where the plug-dropping head turned out to be a substantial distance from the rig floor, the hoses provided with the hydraulic system would not be long enough to reach the control panel meant to be mounted on the rig floor. Instead, in order to make the hoses deal with these unusual placement situations, the actual control panel itself had to be hoisted off the rig floor. This, of course, defeated the whole purpose of remote operation. Additionally, the portions of the dropping head to which the hydraulic lines were connected would necessarily have to remain stationary. This proved somewhat undesirable to operators who wanted the flexibility to continue rotation as well as up or down movements during the cementing operation. Similar such remote-control hydraulic systems are illustrated in U.S. Patent 4,427,065; 4,671,353.

Yet other systems involve the pumping of cement on the rig floor to launch a ball or similar object, the seating of which would urge the cementing plug to drop. Typical of such a system is U.S. Patent 5,095,988. U.S. Patent

4,040,603 shows the general concept of a plug-release mechanism using a hydraulic circuit mounted on the rig floor. U.S. Patent 5,033,113 shows generally the concept of using an infrared receiver to trigger the operation of a device such as an electric fan.

One type of previously used plug-dropping head is the model TD put out by Baker Oil Tools. This device has a plug stop to retain the plug, with a shifting sleeve which in a first position allows the flow to bypass around the plug being retained by the plug stop. Upon manual turning of a set screw, the sleeve shifts, allowing the plug stop to pivot so that the plug is released. The shifting of the sleeve also closes the bypass around the sleeve and forces pressure on top of the plug so that it is driven down into the wellbore in the cementing operation.

The apparatus of the present invention has been designed to achieve several objectives. By putting together an assembly that can be actuated by remote control from a safe location on the rig floor, the safety aspects of plug dropping have been improved. No longer will an operator be required to go up in the derrick to actuate a single or multiple levers in the context of liner cementing. Use of the apparatus and method of the present invention also eliminates numerous hydraulic hoses that need to be extended from a control panel to the final element necessary to be operated to allow the plug to drop. The plug can be dropped while the rotary table is in operation such that not only rotation but movement into and out of the wellbore is possible as the plug is being released to drop. The equipment is designed to be intrinsically safe to avoid any possibility of creation of a spark which could trigger an explosion. The equipment is compact and economically accomplishes the plug-dropping

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maneuver while the operator stands in a safe location on the rig floor. The actuation to drop can be accomplished on the fly while the plug-dropping head is being rotated or being moved longitudinally. Plug-dropping heads can be used in tandem and be made to respond to discrete signals. This ensures that the plugs are released in the proper order from a safe location on the rig.

SUMMARY OF THE INVENTION

An apparatus and method of dropping a pumpdown plug or ball is revealed. The assembly can be integrally formed with a plug-dropping head or can be an auxiliary feature that is mounted to a plug-dropping head. The release mechanism is actuated by remote control, employing intrinsically safe circuitry. The circuitry, along with its self-contained power source, actuates a primary control member responsive to an input signal so as to allow component shifting for release of the pumpdown plug or ball. Multiple plug-dropping heads can be stacked, each responsive to a discrete release signal. Actuation to drop the pumpdown ball or plug is accomplished even while the components are rotating or are moving longitudinally. Using the apparatus and method of the present invention, personnel do not need to climb up in the derrick to actuate manual valves. There is additionally no need for a rig floor-mounted control panel with hydraulic lines extending from the control panel to remotely located valves for plug or ball release.

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BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows an existing prior art plug-dropping head for which a preferred embodiment has been developed.

Figures 2A and 2B illustrate the plug-dropping head of Figure 1, with a few parts removed for clarity, illustrated with the release mechanism of the apparatus and method of the present invention installed and ready to release.

Figure 3 illustrates the piston/cylinder combination in the initial position before release of the plug.

Figure 4 is the same piston/cylinder combination of Figure 3 in the unlocked position after plug release.

Figure 5 is an end view of the view shown in Figure 2, illustrating the spring action feature.

Figure 6 is a detail of Figure 1, showing the existing pin which is changed to accept the invention.

Figure 7 is a sectional elevational part exploded view of the apparatus.

Figure 8 is a sectional view of the apparatus showing the rack.

Figure 9 is an electrical schematic representation of the transmitter used in the invention.

Figures 10 and 11 represent the electrical schematic layout of the components to receive the signal from the transmitter and to operate a valve to initiate release of a ball or plug.

Figures 12A and 12B are a sectional elevation of the plug-dropping head illustrating the electric motor drive for actuating the lock pin.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

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Figure 1 illustrates a prior art plug-dropping head available from Baker Oil Tools. The preferred embodiment of the apparatus and invention has been configured to be mountable to the plug-dropping head illustrated in Figure 1 as an add-on attachment. However, those skilled in the art will appreciate that an integral plug-dropping head, with the remote-release mechanism which will be described, can be provided without departing from the spirit of the invention.

In the prior design shown in Figure 1, a top connection **1** is supported from the derrick in the customary manner. Top connection **1** is connected to a mandrel **9**, which is in turn connected to a bottom connection **12**. Inside mandrel **9** is sleeve **8**. At the bottom of sleeve **8** is plug stop **10**, which is connected by roll pin **11** to sleeve **8**. In the position shown in Figure 1, plug stop **10** would retain a ball or plug above it since it extends transversely into the central flowpath. With the sleeve **8** shown in the position in Figure 1, flow bypasses a plug (not shown) which is disposed atop plug stop **10**. Flow which comes in through top connection **1** circulates through a bypass passage **13** until it is time to drop the ball or plug. At that time, set screw **3** is operated and turned 180° manually. The turning of set screw **3** releases its hold on sleeve **8** and allows sleeve **8** to drop down. As a result of sleeve **8** dropping down, plug stop **10** can pivot around roll pin **11** and the plug or ball is released. Additionally, sleeve **8** comes in contact with bottom connection **12**, thereby sealing off bypass passage **13**. Thereafter, circulation into top connection **1** can no longer go through bypass passage **13** and must necessarily bear down on the ball or plug in the central port or passage **15**, which

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results in a pressure being applied above the plug or ball to drive it through bottom connection **12** and into the liner being cemented in the well.

As previously stated, the operation described in the previous paragraph, with regard to the prior art tool of Figure 1, at times necessitated sending personnel significant distances above the rig floor for manual operation of set screw **3**. Of course, rotation and longitudinal movement of the tool shown in Figure 1 had to stop in order for set screw **3** to be operated to release sleeve **8**.

Referring now to Figure 2, the tool in Figure 1 is shown with many of the component omitted for clarity. At the top, again, is top connection **1**, which is connected to mandrel **9**, which is in turn connected to bottom connection **12**. Sleeve **8** sits within mandrel **9**, and pin **11** secures the plug stop (not shown) in the position to retain a ball or plug in the position shown in Figure 2. It should be noted that the tool shown in Figure 1 is in the same position when shown in Figure 2. That is, the plug stop **10** retains the plug while the flow goes around the sleeve **8**, through the passage **13**. Ultimately, when sleeve **8** shifts, tapered surface **16** contacts tapered surface **18** on bottom connection **12** to seal off passage **13** and to direct flow coming into top connection **1** through the central passage **15** to drive down the ball or plug into the well-bore.

However, there is a difference between the assembly shown in Figure 2 and the assembly shown in Figure 1. Set screw **3** of Figures 1 and 6 has been replaced by a totally different assembly which eliminates the manual operation with respect to the embodiment shown in the prior art of Figure 1. Instead, a housing **20** has been developed to fit over top connection **1** until it

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comes to rest on tapered surface 22. The housing **20** has a mating tapered surface **24** which, when it contacts tapered surface **22**, longitudinally orients housing **20** with respect to top connection **1**.

Rotational orientation is still properly required. To accomplish this, at least one orienting groove or cutout **26** has been machined into top connection **1**. For each cutout **26** there is an alignment bore **28** in housing **20**. A bolt **30** is advanced through threaded bore **28** until it sticks into and firmly engages cutout **26**. Once at least one bolt **30** is inserted into a cutout **26**, the radial orientation between housing **20** and top connection **1** is obtained. That orientation can be secured with set screws (not shown) inserted through threaded bores **32** and **34**. At that point, not only is housing **20** properly oriented, but its orientation is properly secure. As a result of such orientation, bore **36** in top connection **1** is aligned with bore **38** in housing **20**. Bores **36** and **38** are disposed at an angle with respect to the longitudinal axis of top connection **1**. A preferably square thread **40** is located in bore **36**. Instead of set screw **3** (see Figure 6), a pin **42** (see Figure 7) is installed through aligned bores **36** and **38**. Threads **44** on pin **42** engage thread **40** in bore **36**.

Figure 7 outlines the assembly procedures for the installation of pin **42**. After aligning housing **20**, as previously described, the cover **46** (see Figure 2) is removed, allowing access to bore **38** for installation of pin **42**. Pin **42** is advanced and rotated into threads **40** until tapered surface **48** is in an orientation about 180° opposed from that shown in Figure 7. The orientation of surface **48** is determined by the orientation of bore **50**, which does not extend all the way through pin **42**. Bore **50** is designed to accept a handle **52** (see Figure 2). The orientation of tapered surface **48** is known by the orientation

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of bore **50**. Having aligned tapered surface **48** in a position about 180° opposed from that shown in Figure 7, the gear **54** is fitted over pin **42** and handle **52** is extended into bore **50**. By extending handle **52** through catch **56** on gear **54**, the longitudinal positioning of gear **54** with respect to pin **42** is accomplished. Additionally, the orientation of catch **56** allows initial rotation of both pin **42** and gear **54** to get them into the set position shown in Figure 2.

Prior to securing the gear **54** onto pin **42**, a pair of split sleeves **58** are fitted to housing **20** and secured to each other by fasteners **60**. A rack **62** (see Figure 8) is secured to sleeves **58** via fasteners **64** (see Figure 7).

As shown in Figure 8, gear **54** meshes with rack **62** such that rotation of pin **42** will rotate sleeves **58**. Also connected to sleeves **58**, as shown in Figure 8, are lug or lugs **66**. In the preferred embodiment there are two lugs **66** secured to sleeves **58** (see Figure 5). Typically for each one, a bolt **68** extends through a piston **70** to secure the piston **70** to lug **66** (see Figures 5 and 8). The piston **70** is an elongated member that extends through a cylinder **72** and is sealed thereto by O-ring seal **74**. Disposed between piston **70** and cylinder **72** is floating piston **76**, which is sealed against cylinder **72** by seal **78** and it is further sealed against piston **70** by seal **80**. A first port **82** allows fluid communication into cavity **84**, which is formed between cylinder **72** and piston **70** and between seal **74** on piston **70** and seal **80** on floating piston **76**. A second port **86** is also disposed in cylinder **72** and communicates with cavity **88**. Cavity **88** is disposed between piston **70** and cylinder **72** on the other side of seal **74**.

Cylinder **72** has a mounting lug **90**. Bolt **92** secures cylinder **72** in a pivotally mounted orientation to housing **20**.

Referring back to lugs **66**, each has a bracket **94** (see Figure 5) to secure an end of spring **96**. A lug **98** is rigidly mounted to housing **20** (see Figure 8) and secures the opposite end of spring **96**. Spring **96** extends spirally around sleeves **58**.

It should be noted that while one particular piston cylinder assembly has been described, a plurality of such identical assemblies or similar assemblies can be used without departing from the spirit of the invention. There are two in the preferred embodiment. In essence, the preferred embodiment illustrates the preferred way to accomplish a desired movement which is responsive to a particular signal for remote release of the ball or plug.

The first port **82** has a line **100** leading to a check valve **102** and a commercially available, intrinsically safe solenoid valve **104** mounted in parallel (see Figure 3). The use of check valve **102** is optional. Coming out of solenoid valve **104** is line **106** which leads back to second port **86**. Cavities **84** and **88**, as well as lines **100** and **106** are filled with an incompressible fluid. Solenoid valve **104** is electrically operated and is of the type well-known in the art to be intrinsically safe. This means that it operates on such low voltage or current that it will not induce any sparks which could cause a fire or explosion. The electrical components for the apparatus **A** of the present invention are located in compartment **108** of housing **20** (see Figure 8). A sensor **110** (see Figures 3 and 8) is mounted in each of bores **112** in housing **20**. Each of the sensors **110** is connected to the electronic control system **114**. The power for the electronic control system **114** comes from a battery **116**. Sen–

sor **110** receives over the air a signal **118** from a control **120**. In the preferred embodiment, the drilling rig operator holds the control **120** in his hand and points it in the direction of sensors **110**, which are distributed around the periphery of housing **20** and oriented in a downward direction. The preferred embodiment has six sensors **110**. The rig operator points the control **120**, which is itself an intrinsically safe device, which emits a signal **118** that ultimately makes contact over the air with one of sensors **110**. The signal can be infrared or laser or any other type of signal that goes over the air and does not create any explosive fire or other hazards on the rig. The effect of a signal **118** received at a sensor **110** is to actuate the control system **114** to open solenoid valve **104**.

However, prior to explaining the actuation of the release, the initial set-up of the apparatus **A** needs to be further explained. As previously stated, pin **42** is installed in a position which is the fully released position. That position is, in effect, about 180° different from the orientation shown in Figure 2. With that initial installation, gear **54** is secured to rack **62**. At that point in time, the cylinder **72** is disposed in the position shown in Figure 4, with the spring **96** fully relaxed except for any preload, if built in. When handle **52** is given a 180° rotation, it moves rack **62**, which is connected to sleeves **58** as are lugs **66**. Accordingly, 180° rotation of handle **52** has the net effect of rotating lugs **66** away from bracket or brackets **98** about 30°–45°. The difference in position of lugs **66** with respect to bracket **98** is seen by comparing Figures 3 and 4.

As a result of the 180° rotation of handle **52**, pin **42** is now in the position shown in Figure 2. By moving lugs **66** away from bracket **98**, spring **96**

has been stretched. In order to accommodate the rotational movement induced by handle **52**, piston **70** must move to a position where it is more extended out of cylinder **72**. In making this movement, cavity **88** must grow in volume while cavity **84** shrinks in volume. As a result, there is a net transfer of fluid, which could be oil or some other hydraulic fluid, through conduit **100** as cavity **84** is reduced in volume, through check valve **102**, if used, and back into conduit **106** to flow into cavity **88** which is increasing in volume. During this time, of course, floating piston **76** experiences insignificant net differential pressure and merely moves to accommodate the change in volume of cavity **84**. It should be noted that if check valve **102** is not used, the operator must use control **120** to trigger valve **104** to open prior to rotating handle **52**. This is because without check valve **102**, if valve **104** remains closed, it will not be possible to turn handle **52** because the rack **62** will not be free to move because piston **70** will be fluid-locked against movement into or out of cylinder **72**. Therefore, if an assembly is used without check valve **102**, the operator must ensure that valve **104** stays open as the orientation is changed from that shown in Figure 4 to that shown in Figure 3. In the preferred embodiment, a timer can be placed on valve **104** so that when it is triggered to open by control **120**, it stays open for a predetermined time (about 4 minutes), thus giving the components time to make their required movements, both in the set-up and the release modes.

The result of the initial rotation of handle **52** about 180° in the preferred embodiment is that pin **42** suspends sleeve **8**, which keeps plug stop **10** supporting the ball or plug **122** (see Figure 7).

When it is time to release the ball or plug **122**, the operator, standing in a safe location on the rig floor, aims the control **120** toward sensors **110**. Having made contact over the air with a signal **118** transmitted from control **120** to one of the sensors **110**, the control system **114** is actuated to open valve **104**. When valve **104** is opened, the force in expanded spring **96** draws lugs **66** rotationally toward bracket **98**. This is allowed to happen as fluid is displaced from cavity **84** through line **100** through valve **104** back through line **106** to cavity **88**. As lug **66** rotates due to the spring force which is now no longer opposed by the hydraulic lock provided by having valve **104** in the closed position, the rotation of sleeve **58** rotates rack **62**, which in turn rotates gear **54**, which in turn rotates pin **42** from the position shown in Figure 2 approximately 180°. This results in the release of sleeve **8** so that it can shift downwardly as previously explained. The downward shifting of sleeve **8** allows plug stop **10** to pivot on roll pin **11**, thus removing the support for the ball or plug **122**. The ball or plug **122** can drop. Its downward progress toward the liner being cemented can also be assisted by pumping down on top of the plug due to passage **13** being cut off upon shifting of sleeve **8**, as in the original design shown in Figure 1.

It should be noted that the housings **20** can be stacked in series, each equipped with sensors **110** that respond to different signals so that if there is a stack of housings **20** in use for a particular application requiring several plugs to be dropped, the sensitivity of sensors **110** on different housings **20** to different signals ensures that the plugs are dropped in the proper order. Accordingly, a separate controller **120** is provided for each apparatus **A** to be used in series, and aiming one controller with a discrete signal to a sensor

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110 will not actuate the apparatus **A** unless the specific signal that sensor **110** is looking for is received. Alternatively, a single controller **120** can be programmed to give different signals **118** in series to accomplish release in the proper sequence.

The control **120** is further illustrated in Figure 9. Control **120** comprises a hand-held transmitter having several components. The transmitter includes a tone generator **101**, which generates a multiplicity of frequencies. In the preferred embodiment, the tone generator **101** generates 5 frequencies comprising 150 Hz, 300 Hz, 600 Hz, 1200 Hz, and 2400 Hz. Additionally, the tone generator **101** creates a carrier frequency of 38 kHz. The frequencies generated by the tone generator **101**, except for the carrier frequency, are passed through a micro- sequencer **103**, and ultimately to a mixer **105** where the carrier signal is mixed with the other frequencies generated. The mixed signal is then passed to an amplifier or power driver **107** for ultimate reception at sensors **110** (see Figure 10). As can be seen from the table which is part of Figure 9, a four-button selector is provided on the transmitter control **120**. The first frequency sent, regardless of the combination selected, is 150 Hz, and the last signal sent is 2400 Hz. It should be noted that selecting different signal combinations on the control **120** will result in actuation of a different ball or plug **122** in an assembly involving a stack of units.

Referring now to Figure 10, any one of the sensors **110** can pick up the transmitted signal and deliver it to the pre-amp and demodulator **109**. The carrier frequency of 38 kHz is eliminated in the pre-amp and demodulator, and the individual frequency signals sent are sensed by the various tone decoders **111**. Each of the tone decoders **111** are sensitive to a different

frequency. When the tone decoder for the 150 Hz detects that frequency, it resets all of the latches **113**. The latches **113** emit a binary output dependent upon the input from the tone decoders **113**. When the last frequency is detected, that being the 2400 Hz frequency at the decoder **111**, the latch **113** associated with the decoder for the 2400 Hz frequency enables the decoder **115** to accept the input from the remaining latches **113** to generate a suitable output which will ultimately trigger valve **104** to open. Again, depending on the binary input to the decoder **115**, discrete signals result as the output from decoder **115**, which result in a signal transmitted to one shot **117**, shown in Figure 11. The one shot **117** triggers a timer **119**, which in the preferred embodiment is set for keeping the valve **104** in the open position for 4 minutes. The signal to timer **119** also passes to solenoid driver **121**, which is a switch that enables the solenoid **123** to ultimately open valve **104**. As a safety precaution to avoid release of any ball or plug **122** if the power supply becomes weak or is otherwise interrupted, there is a power on/off detector **125**, which is coupled to a delay **127**. If the available power goes below a predetermined point, the solenoid **123** is disabled from opening. Thereafter, if the power returns above a preset value, the requirements of time in delay **127** must be met, coupled with a subsequent signal to actuate solenoid **123**, before it can be operated. The power supply to the control circuits is provided by a plurality of batteries that are hooked up in parallel. These batteries are rechargeable and are generally recharged prior to use of the assembly on each job. The batteries singly are expected to have sufficient power to conclude the desired operations.

In another safety feature of the apparatus, in making the initial rotation of handle **52** to set the apparatus **A** up for release, if for any time during the rotation of handle **52** it is released, check valve **102** will prevent its slamming back to its original position due to spring **96**, which could cause injury to personnel. By use of check valve **102**, the initial movement of handle **52** is ensured to be unidirectional so that it holds its ultimate position when released simply because the fluid in the circuit in lines **100** and **106** cannot flow from conduit **106** back to conduit **100** with check valve **102** installed and solenoid valve **104** closed.

The preferred embodiment for actuation of the apparatus, which comprises a more recently developed improvement on the release mechanism previously described, will now be described in more detail.

Referring to Figures 12A and 12B, the apparatus has a top sub **150** connected to a body **152** at thread **154**, which is sealed by seal **156**. At its lower end, the body **152** is connected to bottom sub **158** at thread **160**, which is sealed by seal **162**. The combination of the top sub **150**, body **152**, and bottom sub **158** defines a central passage **164**. Mounted within passage **164** is sleeve **166**. Sleeve **166** has a reverse shoulder **168** near its upper end **170**. Lock pin **172** has a support surface **174** which, when rotated 180° from the position shown in Figure 12A, catches the reverse shoulder **168** to support the sleeve **166**. Within the sleeve **166** is support plate **176**, which is pivoted at pivot pin **178**. The support plate **176** has an extending segment **180** which extends beyond the pivot **178** to engage a shoulder **182** on the body **152** in the position shown in Figure 12B. The lower end **184** of sleeve **166** has a taper **186** which ultimately catches on taper **188** of bottom sub **158**. Thus, in

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the position shown in Figures 12A and 12B, the surface **174** has been rotated out of the way from reverse shoulder **168** so that the sleeve **166** is now free to fall until taper **186** bottoms on taper **188**. When this occurs, the plug **190** can be pumped down as applied pressure from uphole in passage **164** launches the plug **190**. Since there can be no circulation on the outside of sleeve **166** when taper **186** hits taper **188**, the full pumping force applied through passage **164** bears down on the plug **190** to drive it down the well. Those skilled in the art will appreciate that the downward motion of sleeve **166** in turn allows the support plate **176** to pivot 90° counterclockwise to allow the plug **190** to be pumped down the hole.

The actuation system for lock pin **172** will now be described. Referring to Figure 12A, the lock pin **172** is mounted concentrically to a lock pin sleeve **192**. Seal **194** seals around the outside of sleeve **192** while seals **196** and **198** seal between the lock pin **172** and the sleeve **192**. Connected to lock pin **172** is gear **200**. Gear **200** is outwardly biased toward gear **202** by spring **204**. Stop plate **206** has a pin **208** extending therefrom and into a groove **210** in gear **200**. The groove **210** is arcuate and generally permits rotation of gear **200** of approximately 180° before the end of groove **210** engages the gear **200**, thus arresting any further rotation.

The drive system consists of a motor **212**, enclosed in an annular enclosure **214**. Seals **216–224** in effect seal off annular enclosure **214**. Also located within the annular enclosure **214** is a battery pack and control system, represented schematically as **226**. The battery pack **226** can be recharged through a receptacle **228**. A series of downwardly facing openings **230** house

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within them signal receivers **232**, which are connected by a coaxial cable assembly **234** into the control system **226**.

The motor **212** is connected to a gear–reducer **236**, which is in turn connected to an output shaft **238**. A shaft seal **240** surrounds shaft **238**. As a result, the enclosure **214** can be isolated from the surrounding environment with a positive pressure of an inert gaseous material, preferably nitrogen. As a result, any sparking which occurs from the motor **212** driven by the battery pack **226** through its control system will present no hazards of explosion from any flammable materials existing outside of the enclosure **214**. The shaft **238** has a bevel gear **242**, which meshes with a mating gear **244**. Gear **244** is connected to gear **202** by a common shaft **246**, which is in turn supported by a brass bearing **248**.

When actuated to release a plug **190**, the control system **226** energizes the motor **212** to turn until gear **200** can turn no further because groove **210** has engaged the pin **208**. As previously stated, this generally occurs when the lock pin **172** is rotated 180° to the position shown in Figure 12A. The control system **226** senses an increase in current demand at motor **212** which generally occurs when further movement of lock pin **172** is impeded by pin **208**. The control system **226** stops the motor **212** and runs it in a reverse direction for a few degrees to free up groove **210** of the gear **200** from pin **208**. Control system **226** can also, on a timer basis, provide a signal through one of the openings **230** to indicate that a predetermined time has elapsed before the full rotation of lock pin **172** has occurred. The assembly shown in Figures 12A and 12B can be reset manually through access hole **248**. A wrench can be inserted through opening **248** onto the end **250** of lock pin **172**.

End **250** accommodates the wrench that goes through the hole **248** on its way into contact with gear **200**. The wrench has a recess in it to accommodate the end **250** as the gear **200** is displaced. The wrench engages gear **200** to facilitate its disconnection from gear **202**. The gear **200** can be displaced by pushing against it and compressing the spring **204**. In that manner, the gear **200** is pushed out of engagement with gear **202**. Once there is a disengagement between gears **200** and **202**, the tool (not shown) stuck through the opening or hole **248** can reset the lock pin **172** in a position where it will grab the reverse shoulder **168** of sleeve **166** which, prior to turning lock pin **172**, will have already been replaced into the position shown in Figures 12A and 12B. In other words, from the position shown in Figure 12A, the tool, having disengaged gears **200** and **202**, can invert surface **174** so it once again would catch on reverse shoulder **168**. The release process can then be repeated for another launching of a plug **190**.

It should be noted that the drive between the gear-reducer **236** and the lock pin **172** can be accomplished in different ways, such as by one flexible shaft therebetween. The important feature that is needed is a clutching mechanism so that after the lock pin **172** is actuated into the position shown in Figure 12A, it can be manually reset to the position where it supports sleeve **166**. Those skilled in the art will appreciate that in emergency situations or if for any other reason the control system/battery pack **226** fails to operate, the lock pin **172** can be rotated manually using a tool inserted through opening or hole **248**. In other words, for example, a singular continuous flexible shaft can be used from the gear-reducer **236** to what is now illustrated as gear **202**. If

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that is done, there is still the clutching feature, as illustrated in Figure 12A, where the gear **200** can be disengaged from gear **202** for reset.

It should also be noted that seal **252** assists in preventing the entrance of moisture into enclosure **254**.

This mode of actuating the lock pin **172** is preferred to the multi-linkage hydraulic circuit design earlier described in that additional reliability is obtained by simplifying the drive for the lock pin **172**. Using the two linkage systems previously described presents design issues that need to be dealt with such as the cleanliness of the interior of the hydraulic system because contaminants can affect the operation of the solenoid **104** or the check valve **102** as described in Figure 3. Additionally, the use of parallel systems could create a situation where one of the two primarily carries the entire load while the other one carries no load. Thus, the embodiment now described for actuating the lock pin **172** is preferred. The motor **212** and gear-reducer **236** are isolated in a pressurized environment in enclosure **214**. The environment in chamber **214** is also inert; thus, the possibility of the presence of any flammable fluids within the enclosure **214** is eliminated.

Those skilled in the art will appreciate that the specific embodiment illustrated in Figures 12A and 12B is particularly designed to fit into a comparable enclosure as the linkage and hydraulic system method of operating the sleeve illustrated in Figures 2A and 2B, but a different enclosure can still be used without departing from the spirit of the invention. Any number of different power transmission modes can be used between the electric motor **212** and the lock pin **172** without departing from the spirit of the invention.

The foregoing disclosure and description of the invention are illustrative and explanatory thereof, and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made without departing from the spirit of the invention.

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